Effectiveness of hand and rotary instrumentation for removing a new synthetic polymer-based root canal obturation material (Epiphany) during retreatment

J. F. Schirrmeister, K. M. Meyer, P. Hermanns, M. J. Altenburger & K.-T. Wrbas
Department of Operative Dentistry and Periodontology, Albert-Ludwigs-University, Freiburg, Germany

Abstract

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Aim To evaluate the effectiveness of hand and rotary instrumentation for removal of vertically compacted Epiphany and gutta-percha during retreatment.

Methodology Sixty extracted single-rooted maxillary central incisors were enlarged to size 40 using FlexMaster instruments. The teeth were randomly divided into four groups of 15 specimens each. The canals of two groups were obturated using vertically compacted Epiphany. The others were filled with vertically compacted gutta-percha and AH Plus sealer. One Epiphany group and one gutta-percha group was reinstrumented with Gates Glidden burs and Hedström files. In the other two groups, obturation material was removed using Gates Glidden burs and RaCe rotary instruments. After clearing the roots, the area of remaining obturation material on the root canal wall was measured using a computer image analysis program. Statistical analysis was performed using Repeated Measures Analysis of Variance and ANOVA.

Results Retreatment of specimens obturated with gutta-percha showed significantly more remaining obturation material than specimens filled with Epiphany ($P < 0.05$). No difference was found between the removal with Hedström files and with RaCe instruments ($P > 0.05$). Regarding the mean time of retreatment and time required for reaching the working length, Hedström files were significantly faster than RaCe instruments ($P < 0.05$). The times did not depend on the kind of obturation material ($P > 0.05$).

Conclusions Vertically compacted Epiphany in combination with Epiphany Root Canal Sealant was removed more effectively than gutta-percha and AH Plus sealer. Hedström files were more rapid than RaCe rotary instruments.

Keywords: Epiphany, gutta-percha, Resilon, root canal retreatment, rotary instrumentation, vertical compaction.

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Introduction

The main goal of non-surgical root canal retreatment is to re-establish healthy periapical tissues following the ineffective root canal treatment or reinfection. The procedure requires the removal of the original root filling, further cleaning and refilling (Stabholz & Friedman 1988). Endodontic hand files, engine-driven rotary files, solvents, heat-carrying and ultrasonic instruments are helpful devices to remove filling material, particularly gutta-percha (Wilcox *et al.* 1987, Wilcox 1989, Friedman *et al.* 1990, Zakariasen *et al.* 1990, Teplitsky *et al.* 1992, Hülsmann & Stotz 1997).

Recently, a new root filling material named Resilon (Resilon Research LLC, Madison, CT, USA; trade name

Correspondence: Dr Jörg Fabian Schirrmeister, Abteilung für Zahnerhaltungskunde und Parodontologie, Universitätsklinik für Zahn-, Mund- und Kieferheilkunde, Hugstetter Str. 55, D-79106 Freiburg i. Br., Germany (Tel.: +49 761 2704910; fax: +49 761 2704762; e-mail: joerg.schirrmeister@uniklinik-freiburg.de).

'Epiphany') was introduced into the market. Based on the polymers of polyester, it contains bioactive glass and radiopaque fillers. It has the same handling properties as gutta-percha. The Resilon core materials, similar to gutta-percha cones, are available in ISO sizes with 0.02, 0.04 and 0.06 tapers, as well as in accessory sizes (Epiphany Points; Pentron Clinical Technologies LLC, Wallingford, CT, USA). Additionally, pellets of this material (Epiphany Pellets; Pentron Clinical Technologies LLC) are available for use with the Obtura II delivery system (Obtura Spartan, Fenton, MO, USA). Epiphany is recommended for the use in combination with a new dual curable dental resin composite sealer Epiphany Root Canal Sealant (Pentron Clinical Technologies LLC). An evaluation of microbial leakage within roots filled with Epiphany demonstrated significantly less leakage than roots filled using gutta-percha and AH 26 with both lateral condensation or vertical compaction techniques (Shipper *et al.* 2004). In an animal model, teeth filled with Epiphany were associated with significantly less apical periodontitis than teeth filled with gutta-percha and AH 26 (Shipper *et al.* 2005).

To date, there is no study concerning retreatment of teeth filled using Epiphany. According to the manufacturer, the new material has the same handling properties as gutta-percha and it should be expected that removal of this material can be performed in a way similar to the removal of gutta-percha. Thus, in the current study, the hypothesis was tested that root canals filled with Epiphany can be retreated using hand and rotary instrumentation in the same manner as canals filled with gutta-percha and conventional sealer.

Materials and methods

Specimen preparation

Sixty extracted human maxillary central incisors of similar length and diameter having one single straight root canal, fully formed apices and no root fillings were used. Soft tissue and calculus were mechanically removed from the root surfaces. The teeth were verified radiographically as having patent canals of curvature <10° (Schneider 1971). Standard access preparation was accomplished using high-speed diamonds and water spray. A size 10 K-type file (VDW Antaeos, Munich, Germany) was placed into the canal until it was visible at the apical foramen. The working length (WL) was established 1 mm short of this length. The incisal edges were resected so that the WL of each tooth was 18 mm.

Canal preparation

FlexMaster instruments size 30/0.06 taper, size 25/0.06 taper, size 20/0.06 taper, size 30/0.04 taper were used in a crown-down manner in combination with a torque-controlled engine (Endo IT professional; Aseptico Inc., Woodinville, WA, USA) at 300 rpm according to the manufacturer's instructions. Instrument size 30/0.04 taper reached the WL. Apical enlargement was performed using size 35/0.02 taper and size 40/0.02 taper. Each instrument was coated with a lubricant containing EDTA (FileCare; Vereinigte Dentalwerke, Munich, Germany) before placement. Root canals were irrigated using 30 mL sodium hypochlorite (5%) through a 31-gauge needle (Endo-Eze Tips; Ultradent Products Inc, South Jordan, UT, USA) during the cleaning and shaping. Furthermore, 5 mL of 17% EDTA were used during and after the instrumentation to remove smear layer.

Canal filling

The root canal of each tooth was dried with sterile paper points. All samples were divided randomly into four groups with 15 specimens each.

In two groups, canals were filled using vertically compacted of gutta-percha with AH Plus sealer (Dentsply DeTrey, Konstanz, Germany). After drying the canals with sterile paper points, a gutta-percha master cone (Obtura Spartan) was fitted apically, coated with sealer and placed into the canal to WL. The master cone was vertically thermoplasticized using a continuous wave of condensation technique (System B; Analytic Endodontics, Orange, CA, USA). A backfill with Obtura II gutta-percha (Obtura Spartan) and condensation with Machtou pluggers (Dentsply Maillefer, Ballaigues, Switzerland) was performed.

In the other groups, roots were filled using vertical compaction of Epiphany (Pentron Clinical Technologies LLC) with Epiphany Root Canal Sealant (Pentron Clinical Technologies LLC) according to the manufacturer's instructions. Therefore, EDTA application was followed by a rinse with sterile water (5 mL) through a 31-gauge needle (Endo-Eze Tips). After drying with paper points, a self-etching primer (Epiphany Primer; Pentron Clinical Technologies LLC) was placed into the canal with a thin needle. Excess primer was removed with paper points. Canals were filled with a master cone of Epiphany (Epiphany Points; Pentron Clinical Technologies LLC) coated with Epiphany Root Canal Sealant using the continuous wave of condensation (System B) technique, backfilled with Epiphany

(Epiphany Pellets; Pentron Clinical Technologies LLC) in an Obtura II gun (Obtura Spartan) and condensed with Machtou pluggers. The coronal surface of the root filling was light-cured for 40 s (Elipar FreeLight 2; 3M Espe, Seefeld, Germany).

The extension of the root canal fillings was limited to 14 mm from the apex so that the volume of obturation material was approximately equal for all the teeth.

To reduce inter-operator variables, each canal was prepared and filled by the same operator (KMM) who was experienced in the continuous wave of condensation technique using Epiphany and gutta-percha.

The access cavities were filled with the composite Tetric Ceram (Ivoclar-Vivadent, Schaan, Liechtenstein) in combination with the total-etch technique and the adhesive Excite (Ivoclar-Vivadent) according to the manufacturer's instructions. Teeth were radiographed in buccolingual and mesiodistal directions to confirm the adequacy of the root filling. All teeth were stored in a humidor at 37 °C for 7 days to allow complete setting of the sealer.

Retreatment technique

After regaining access, the cervical 6 mm of gutta-percha of all roots was removed using Gates Glidden burs 1, 2 and 3 at 1000 rpm. Canals were irrigated with 30 mL sodium hypochlorite (5%) through a 31-gauge needle (Endo-Eze Tips) during the retreatment with the test instruments.

RaCe instruments

One gutta-percha and one Epiphany groups were retreated with RaCe rotary instruments. These files were used in combination with a 4 : 1 contra-angle hand-piece with press button chuck (WD-77M; W&H, Bürmoos, Austria) and a torque-controlled engine Endo IT professional (Aseptico Inc.) at 300 rpm according to the manufacturer's instructions. The canals were reinstrumented in a crown-down manner with RaCe rotary instruments size 40/0.10 taper, size 35/0.08 taper and size 25/0.06 taper. Instrument size 25/0.06 taper reached the WL. Apical enlargement was performed with instrument size 30/0.02 taper, size 35/0.02 taper, size 40/0.02 taper, size 45/0.02 taper and size 50/0.02 taper.

Hedström files

In the other two groups, reinstrumentation was performed using Hedström files. Hand instrumentation was carried out with H-type files with sizes 25, 30, 35, 40, 45 and 50 in a circumferential quarter-turn push-pull filing motion to remove gutta-percha and sealer from the canal.

Preparation was deemed complete when there was no obturation material covering the instruments. A randomly laid down sequence was used to avoid bias towards one of the four groups of instruments. One set of instruments was used for repreparation of five root canals. Each root canal was retreated by one experienced operator (JFS) in order to reduce interoperator variability.

Evaluation

For all roots, four types of data were recorded.

Canal wall cleanliness

After reinstrumentation, the specimens were decalcified in 5% nitric acid for 72 h, washed for 4 h and dehydrated in increasing concentrations of alcohol (80% for 12 h, 90% for 1 h and 99% for 3 h). The roots were cleared subsequently using methyl salicylate. The amount of filling material on the canal walls was imaged in a standardized way on a black background in buccolingual and mesiodistal directions and measured in mm^2 using image analyser software (Comef 4.0; OEG Messtechnik, Frankfurt, Germany) connected to a stereomicroscope with 6.5× magnification via a CCD-sensor. Because of the black background, the residual obturation material (e.g. white Epiphany, yellow AH Plus) was verified. All measurements were evaluated by a single observer (PH) who was blinded to group assignment.

Time for reaching the original WL

The time elapsed from entering the canal with the first Gates Glidden bur until reaching the original WL was measured with a stopwatch.

Total time for retreatment

The time required for reaching the WL and for removal of gutta-percha and sealer from starting the first Gates Glidden bur until the completion of the reinstrumentation was recorded.

Procedural errors

The number and type of fractured and deformed instruments were recorded.

Analysis

Statistical analysis was performed using the Repeated Measures Analysis of Variance for analysis of areas of

remaining filling material and using ANOVA for analysis of the working times. Level of significance was set at $P \leq 0.05$. All statistics were performed using SAS 8.2 (SAS Institute Inc., Cary, North Carolina, USA).

Results

Remaining filling material was observed in all groups. Both after retreatment with Hedström files and after retreatment with RaCe instruments, specimens filled with gutta-percha showed significantly more remaining filling material than specimens filled with Epiphany imaged in buccolingual and mesiodistal directions ($P < 0.05$). No statistically significant difference was found between the removal with Hedström files and the removal with RaCe instruments concerning remaining material, even though there were lower means for RaCe than for Hedström files in the gutta-percha group ($P > 0.05$; Table 1). No interaction between kind of instrument and obturation material was observed ($P > 0.05$).

Working length was regained in all canals. Regarding the mean time of retreatment and time required for reaching the WL, Hedström files removed both Epiphany and gutta-percha significantly faster than RaCe instruments ($P < 0.05$). The times did not depend on the kind of filling material ($P > 0.05$; Table 2). There was no interaction between the instrument and obturation material ($P > 0.05$).

In all groups, no separated and no permanently deformed files were noted.

Discussion

Removal of filling material is an important factor in root canal retreatment because it allows chemomechanical reinstrumentation and redisinfection of the root canal system (Bergenholtz *et al.* 1979). To date, it has not been proven that complete removal of filling materials will ensure success of root canal retreatment and that remaining material will cause the retreatment to fail. However, removing as much filling material as possible from inadequately prepared and/or filled root canal systems would appear to be essential in order to uncover the remaining necrotic tissues or bacteria that may be responsible for periapical inflammation and persistent disease.

Table 1 Areas of remaining obturation material (mm^2)

Obturation material	Instruments	Area 1		Area 2	
		mean	SD	mean	SD
Epiphany	Hedström	1.74	1.38	1.50	1.19
Gutta-percha	Hedström	3.97	2.20	4.40	2.45
Epiphany	RaCe	1.48	1.44	1.58	1.55
Gutta-percha	RaCe	2.51	1.44	2.55	1.21

Means and SD of remaining obturation material imaged in buccolingual (area 1) and mesiodistal directions (area 2).

Table 2 Preparation time (min : s)

Obturation material	Instruments	WL		CR	
		mean	SD	mean	SD
Epiphany	Hedström	1 : 56	0 : 29	4 : 04	0 : 54
Gutta-percha	Hedström	2 : 20	0 : 35	4 : 26	1 : 05
Epiphany	RaCe	3 : 08	0 : 31	4 : 57	0 : 39
Gutta-percha	RaCe	3 : 17	0 : 20	5 : 05	0 : 27

Mean time and SD for reaching the working length (WL) and for complete retreatment (CR).

In contrast to most studies concerning retreatment of canals filled using lateral condensation (Hülsmann & Stotz 1997, Imura *et al.* 2000, Sae-Lim *et al.* 2000, Betti & Bramante 2001, Hülsmann & Bluhm 2004, Schirrmeister *et al.* 2005a,b), root canals in this study were filled by vertical compaction.

Rotary instrumentation was performed using the RaCe files. In two recent studies, RaCe instruments removed gutta-percha and sealer better than FlexMaster instruments in straight premolars and better than FlexMaster and ProTaper in curved mandibular premolars (Schirrmeister *et al.* 2005a,b). Apical enlargement was performed with 0.02 taper RaCe instruments and not with 0.04 taper instruments in order to produce a taper equivalent to that of the Hedström group for end-point preparation. Furthermore, 0.02 tapered RaCe instruments were used for apical enlargement in studies concerning shaping ability and cleaning effectiveness (Schäfer & Vlassis 2004a,b). The manufacturer of RaCe recommends between 300 and 600 rpm (http://www.fkg.ch/pdf/FKG-Race%20brochure-01B-AN.pdf). In the present study, speed was set at 300 rpm to align with recent studies on RaCe instruments, where 250 (Yoshimine *et al.* 2005), 300 (Schirrmeister *et al.* 2005a) and 315 rpm were used (Rangel *et al.* 2005). It was found that increased speed shortened the working time during the retreatment using Quantec rotary instruments (Tycom, Irvine, CA, USA), but it showed no effect on cleanliness (Bramante & Betti 2000). Thus, a higher speed could have shortened the time required for reinstrumentation in the RaCe groups. Hedström files were used for hand reinstrumentation as in many previous studies

(Hülsmann & Stotz 1997, Imura *et al.* 2000, Betti & Bramante 2001, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004, Schirrmeister *et al.* 2005a,b).

In the present study, no solvent was used. Preliminary tests measuring the depth of penetration of a dental explorer showed that eucalyptol had nearly no softening effect on Epiphany. Therefore, both Epiphany and gutta-percha were retreated without the use of solvent because the missing softening effect on Epiphany should not have an impact on the outcome of the study. Whether this effect on Epiphany is more pronounced for solvents other than eucalyptol needs to be clarified. A recent study showed no significant difference between removing gutta-percha with and without eucalyptol regarding time required for retreatment using rotary instruments as well as Hedström files (Hülsmann & Bluhm 2004). In the apical part, the use of eucalyptol resulted in marginally better root canal cleanliness (Hülsmann & Bluhm 2004). Thus, the disadvantage of not using a solvent in the gutta-percha groups was considered to be negligible. It could be argued that chloroform would have shortened the time required for reinstrumentation or marginally increased cleanliness as it dissolves gutta-percha better than eucalyptol (Kaplowitz 1990, 1991).

In previous studies, remaining filling material was assessed radiographically (Ferreira *et al.* 2001) or roots were split longitudinally and residual obturation material was measured linearly (Imura *et al.* 2000) or using evaluation scales (Hülsmann & Stotz 1997, Sae-Lim *et al.* 2000, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004): e.g. severe, moderate, mild or no retreatment debris. In the present study, the roots were cleared to allow the measurement of the area of residual obturation material because remaining gutta-percha or sealer might get lost by splitting the roots longitudinally. This method proved successful in two previous studies (Schirrmeister *et al.* 2005a,b). Resilon is suspected to be degenerative (Tay *et al.* 2005). However, preliminary tests of the present study did not show an influence of the clearing procedure using the above-mentioned concentrations of nitric acid, alcohol and methyl salicylate on the area of remaining obturation materials within the root canal.

In the present study, residual root canal filling material was observed in all groups. The presence of gutta-percha and sealer pressed in deep grooves and depressions on dentine walls in the apical third may well explain the presence of these less-instrumented areas.

Even though gutta-percha and AH Plus do not adhere as well to the canal wall as Epiphany, removal of Epiphany left significantly less filling material than removal of gutta-percha and AH Plus. This may be explained by the formation of a 'monoblock' in the Epiphany group (Teixeira *et al.* 2004). The Epiphany material (points or pellets) combined with the Epiphany dual cured resin sealer bind together in the canal. Thus, sealer might be better removed if it is bound together with the core material. In the gutta-percha group, there was no chemical interaction between gutta-percha and AH Plus sealer. Therefore, remaining sealer brushed on the canal wall may have increased the area of remaining material.

The areas of remaining filling material did not depend on the type of instrument used. In contrast, in a recent study on retreatment of straight mandibular premolars filled with laterally condensed gutta-percha, the Hedström group revealed significantly larger areas of remaining material than the RaCe group (Schirrmeister *et al.* 2005a). In another study using curved canals, there was no significant difference between Hedström and RaCe imaged in buccolingual direction. However, imaged in mesiodistal direction, in the Hedström group, more remaining obturation material was found than in the RaCe group (Schirrmeister *et al.* 2005b). In the present study, Hedström files also showed higher means of remaining gutta-percha and sealer than RaCe instruments, but the difference was not statistically significant.

The preparation time depended on the choice of instrument, not on the filling material. Hedström files reached the WL significantly faster and removed filling material significantly quicker. This outcome confirms the findings of a recent study about the retreatment of curved canals filled with gutta-percha (Schirrmeister *et al.* 2005b). In another study, RaCe instruments worked faster than Hedström files during the retreatment of straight canals laterally condensed with gutta-percha (Schirrmeister *et al.* 2005a).

The contrast between the outcome of previous studies and the present study may be explained by other master apical sizes (original preparation to apical size 30, reinstrumentation to size 35 in the previous studies) and another kind of filling technique, which may influence the working time and the cleanliness (Baratto Filho *et al.* 2002). Furthermore, in contrast to both previous studies, incisors instead of premolars were used in the present study. It could be that the anatomy of incisors was an advantage for the Hedström group.

Further research on retreatment of severely curved root canals filled with Epiphany is suggested. Moreover, studies will be needed for clarifying the effectiveness of different solvents for Epiphany.

Conclusions

Under the conditions of the present study, removal of vertically compacted Epiphany resulted in less remaining filling material than the removal of vertically compacted gutta-percha. The time required for reinstrumentation did not depend on material.

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